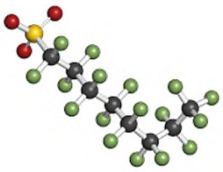


Research Project

PFAS in the Pee Dee Watershed

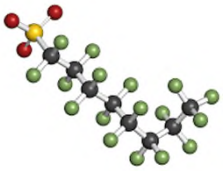
Till J.J. Hanebuth[1], Debra Buffkin[2], and the collaborative CCU/WRA team

[1] Coastal Geosystems Research Lab, Department of Marine Science, Coastal Carolina University (CCU)

Arwen Kintz, Hannah Skipper, Jackson Whitmore + 15 students

[2] Winyah Rivers Alliance (WRA)

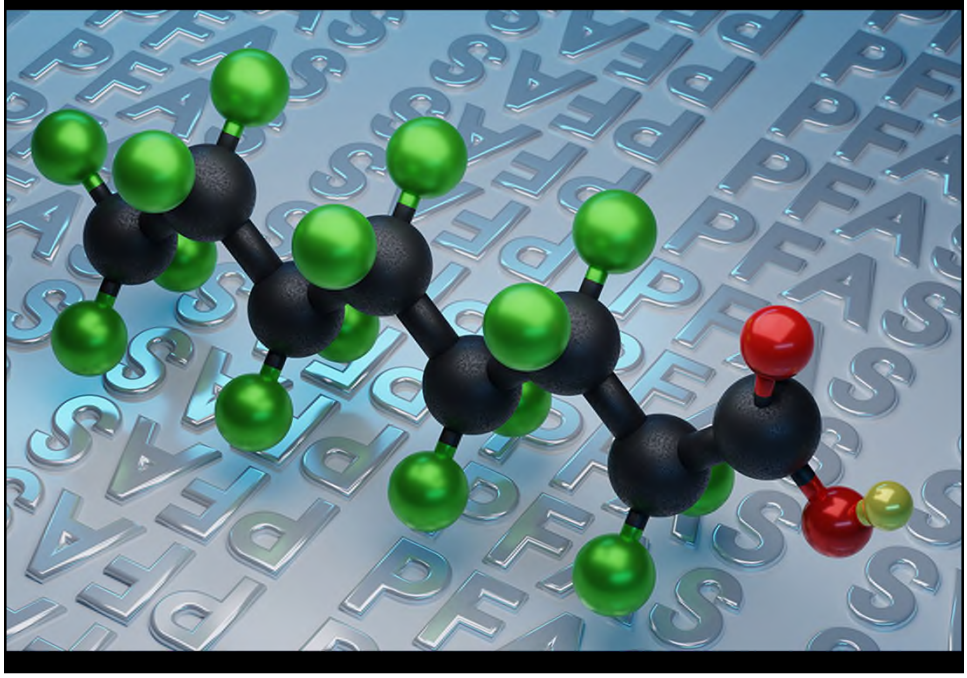
Riverkeepers Erin Donmoyer, Dylan Coleman, Preston Kelly, Avalon Rosenberger



Content:

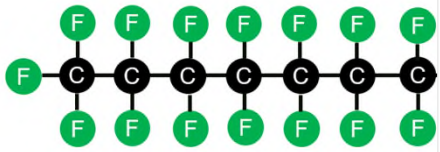
- Introduction: What is PFAS and why should we be alerted?
- History of project: SC DHEC / SC DES PFAS monitoring triggering our project
- Dataset: PFAS in the Pee Dee / lower Winyah Watershed
- Findings: Utilizing PFAS to identify sources, pathways, and accumulation risks
- Outlook: Suggested action items and opportunities for collaboration

What is the PFAS animal?



What is the PFAS substance?

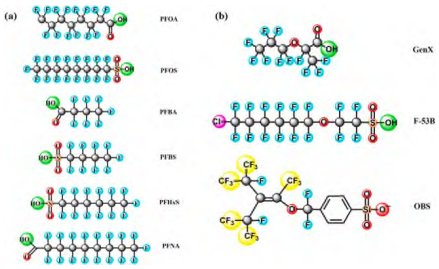
TAIL
Fluorinated
(hydro-/oleophobic)



C Carbon F Fluorine O Oxygen P Phosphorus S Sulphur H Hydrogen

Contaminants of Emerging Concern: **PFAS** = Poly- and Perfluoroalkyl Substances

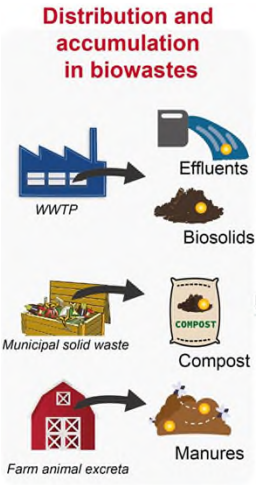
+ Hydrophobic & oleophobic.
+ Usage: Surfactants, lubricants, polymer additive and especially in aqueous film-forming foams.
+ Essential for airports and firefighting.

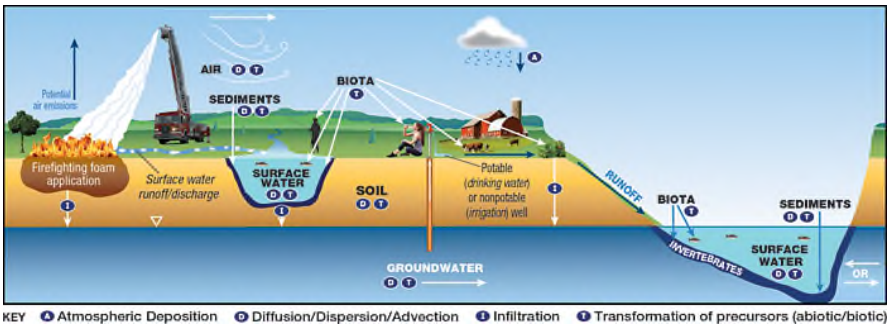


- Adverse effects: genotoxicity, immunotoxicity, neurotoxicity and hepatotoxicity.
- Distribute and accumulate effectively in the air, water, soil, groundwater, tissue.
- "Forever chemicals": long lifespan.
- Group of ca. 15,000 compounds.

Primary vs Secondary PFAS Sources

A. Primary origin	→	Production for daily use
B. Secondary sources	→	Unintended release and distribution





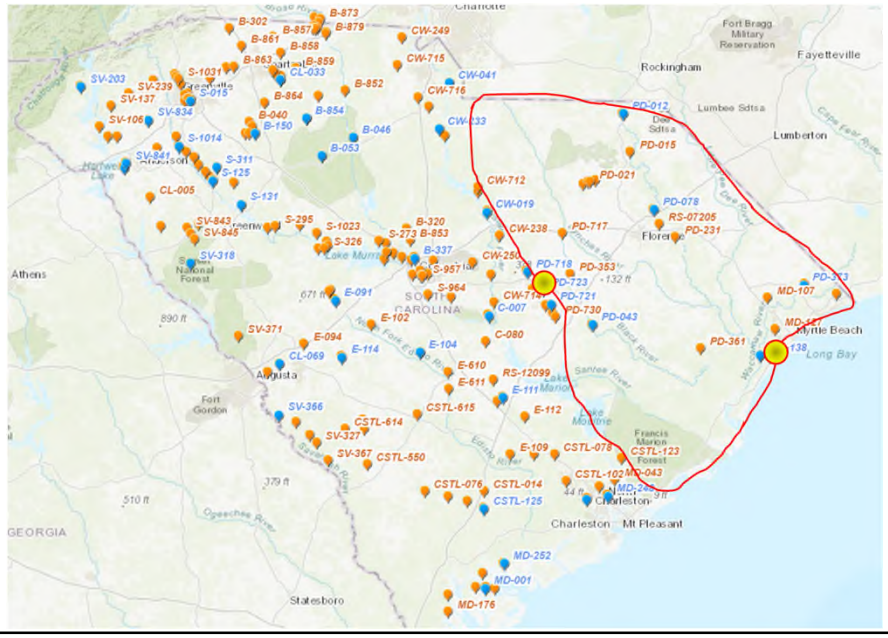
EPA CERCLA / EPCRA (Apr 24)

- **Releases** of PFOA and PFOS **≥1 lb**. within a 24-hour period **to be reported** + newspaper notice.
- Purpose: a) allow for **earlier response** activities; b) help communities with PFOA and PFOS pollution by **holding polluters**, vs the taxpayers, **accountable**; increase transparency.
- The **US DOT** to list and regulate these substances as hazardous materials under the Hazardous Materials Transportation Act.
- ***No response actions required*** as a result of designation or release of a hazardous substance. Designation does not automatically require any investigation or cleanup actions.

CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act.
EPCRA: Emergency Planning and Community Right-to-Know Act.

SC DHEC Bureau of Water

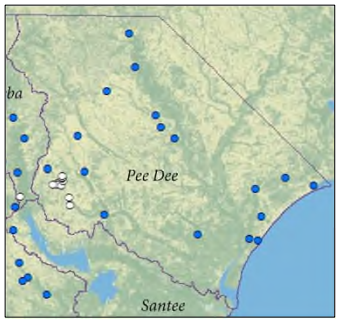
(Quarterly documentation since 7/22)



SC DHEC Bureau of Water

(Quarterly documentation since 7/22)

Surface-water sampling



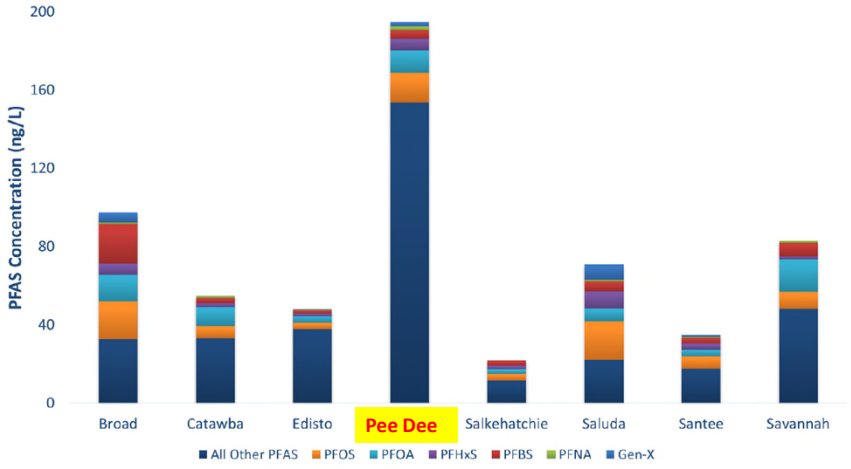
Food-tissue sampling

- PFAS are **ubiquitous** in the South Carolina aquatic environment.
- Only surface water and freshwater fish/oyster tissue investigated.
- **No data on soil, sediment, or suspended (drifting) matter**.

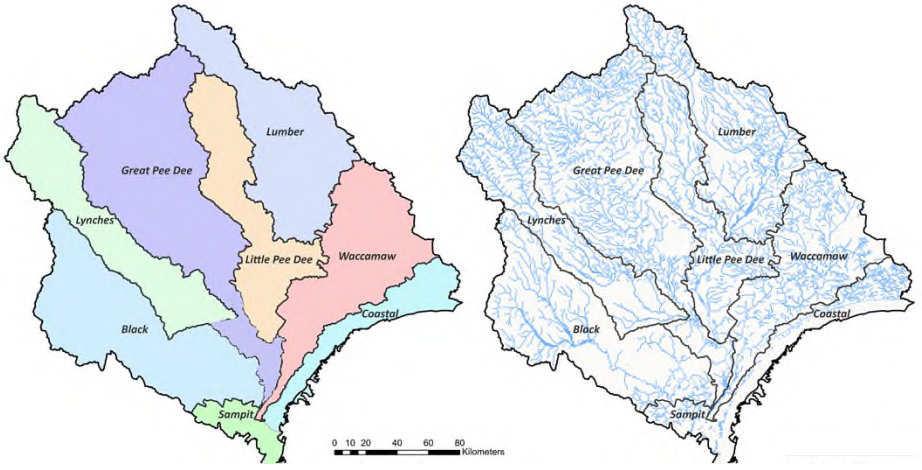
SC DHEC Bureau of Water

(Quarterly documentation since 7/22)

Total PFAS found across the SC watersheds

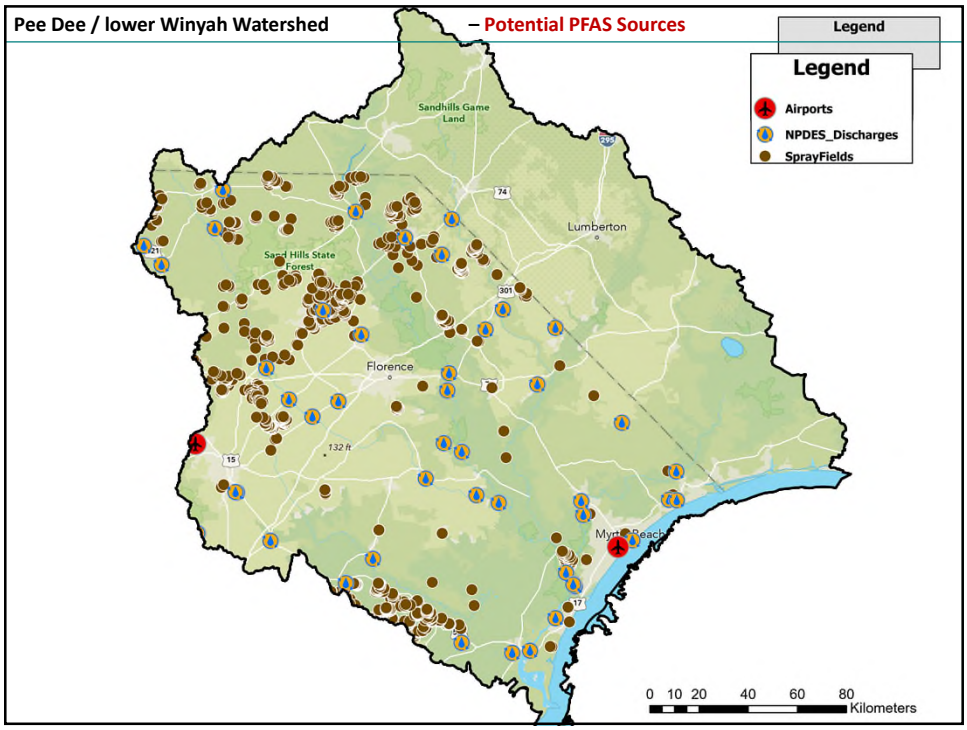


Pee Dee / Lower Winyah Watershed – Hydrology



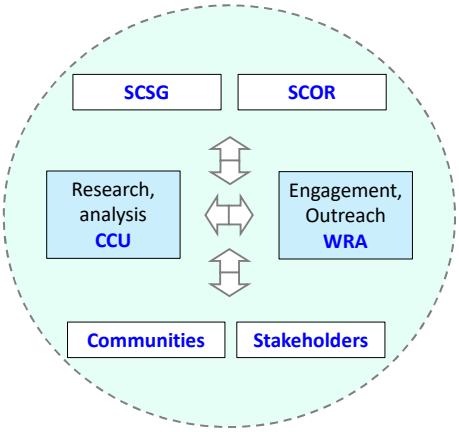
- 12 Counties
- 7 River sub-watersheds
- Numerous tributaries, high hydrological connectivity
- Countless creeks, swamps, wetlands
- Discharging into Winyah Bay (+AIWW)

Pee Dee / lower Winyah Watershed – Potential PFAS Sources

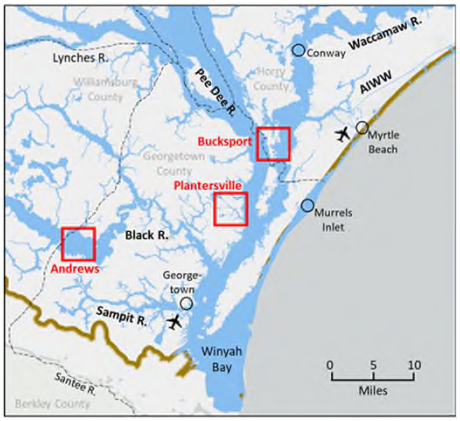


NOAA/SC Sea Grant CEC Research & Outreach Project 'WinyahFlu' (2024-2026)

Project organogram



Specific focus on wetland communities



NOAA/SC Sea Grant CEC Research & Outreach Project 'WinyahFlu' (2024-2026)

Scientific Goals:

1. Building a comprehensive, and publicly accessible **database**.
2. Tracing **sources and pathways** across our coastal lowland region.
3. Analyzing the impact of high-water, high-energy **flooding events**.
4. Attempting a **compound-specific forecast** with regard to a **changing climate**.

Engagement and Outreach Goals:

1. **Educating local communities** about potential impacts to their communities.
2. **Working with community leaders** to assess PFAS data and community-specific impacts.
3. Building a community-driven **collaborative that engages decision-makers** in solutions to address PFAS contamination locally, regionally, and statewide.

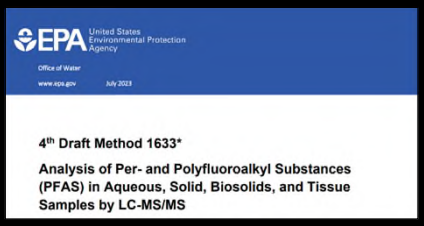
PFAS in the Environment – the Emerging, Hazardous 'Forever' Chemical

Research component

Engagement, Outreach component

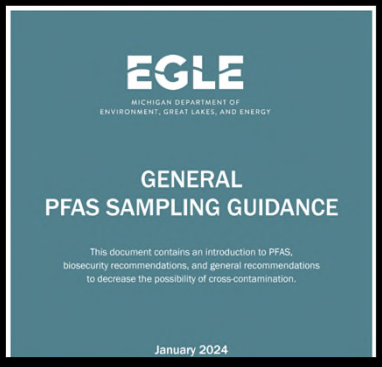
Consequence: Responsible Action?

The CCU-WRA Project: PFAS in the SC Pee Dee Watershed – Preparation


EPA United States Environmental Protection Agency
Office of Water
www.epa.gov July 2023

4th Draft Method 1633*

Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS

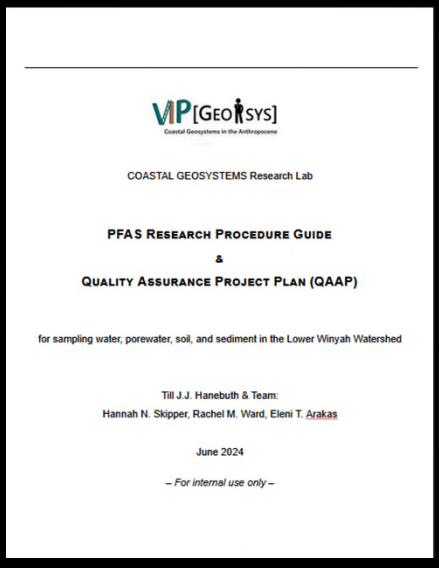

EGLE
MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

GENERAL PFAS SAMPLING GUIDANCE

This document contains an introduction to PFAS, biosecurity recommendations, and general recommendations to decrease the possibility of cross-contamination.

January 2024

Detailed Sampling and Processing Manual


VIP [GEOSYS] Coastal Geosystems in the Anthropocene

COASTAL GEOSYSTEMS Research Lab

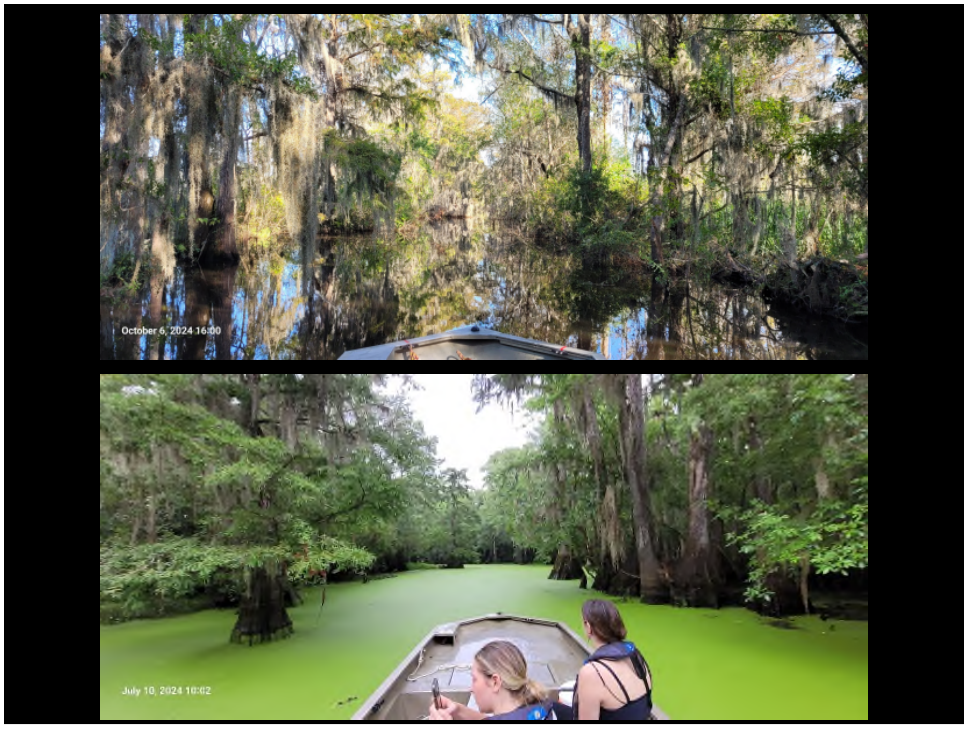
PFAS Research Procedure Guide
&
Quality Assurance Project Plan (QAAP)

for sampling water, porewater, soil, and sediment in the Lower Winyah Watershed

Till J.J. Hanebuth & Team:
Hannah N. Skipper, Rachel M. Ward, Eleni T. Arakas

June 2024

– For internal use only –


October 6, 2024 16:00
July 10, 2024 10:02

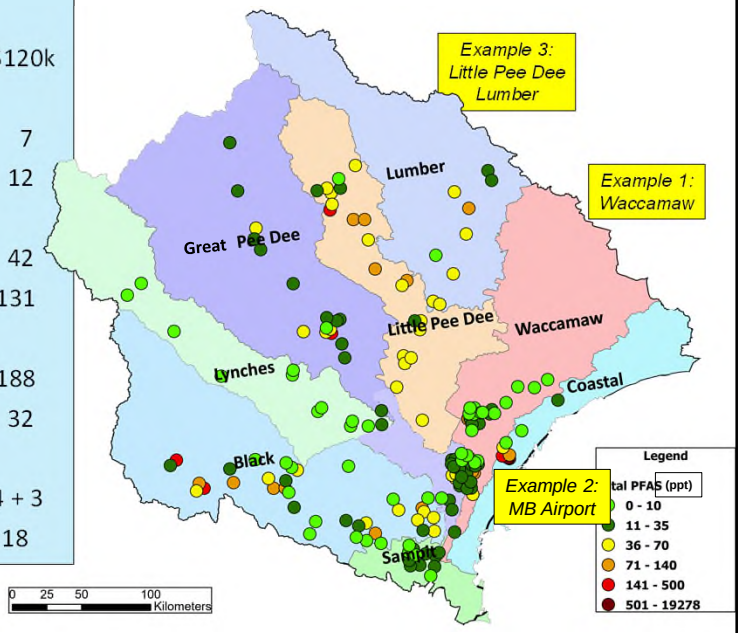

July 22, 2024 12:04


July 17, 2024 07:14

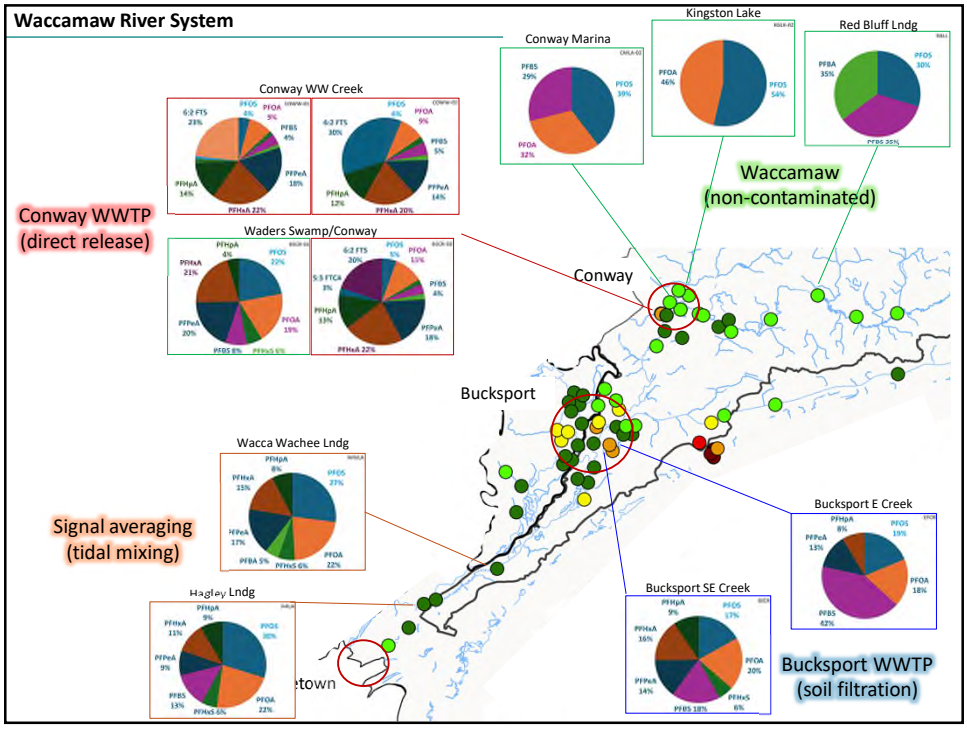
The CCU-WRA Project: PFAS in the SC Pee Dee Watershed

Project Stats:

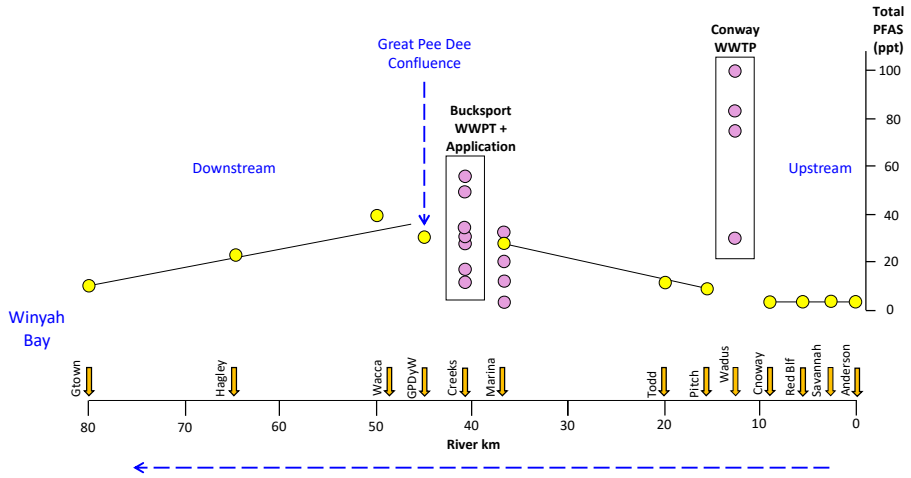
Budget	$120k
Rivers	7
Counties	12
Field days	42
Sampling sites	131
Water samples	188
Soil samples	32
Riverkeepers	4 + 3
CCU Students	18



Waccamaw River System



Waccamaw River Transect (mostly on Oct 5, 2025)

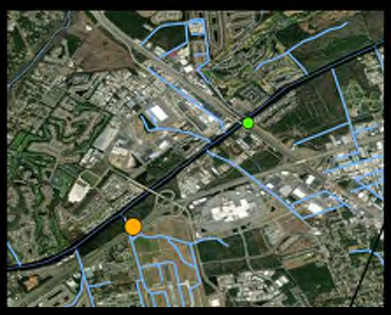


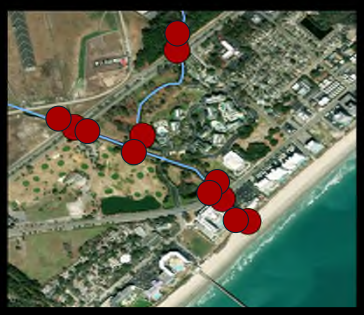
- Tidal river: **bi-directional pumping** → mixing.
- WWTPs: downstream **concentrations double** in the river.
- Estuarine: tidal mixing with ocean water leads to **dilution**.

Some General Findings

- **23 %** of the 188 water samples were **below** the EPA6 recommendation limits.
  (16 % severely contaminated; 8 % reported below detection limit).
- **Concerning PFAS contamination** occurs along most of the rivers despite a comparably low industrial and residential density.
  Clean exceptions are the Lynches and the upper Waccamaw.
- The **maximum** concentration found was **19,220 ppt** total PFAS (EPA drinking water limits: 70 ppt) – former MB Airforce Base & modern MB Airport outflow.
- PFAS **(relative) concentrations** vs PFAS **(absolute) amount/rate** need to be differentiated.
- PFAS accumulation in **soils** is significantly higher PFAS concentrations in water: Soils act as long-term **reservoir** for PFAS release.
- **Tide-related mixing** with brackish/ocean water (dilution) is the only effective natural mitigation process.
- Effects during river **flooding** and **storm-surge** events have not been considered yet due to the lack of such an impact.

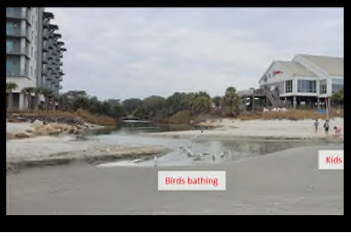
Myrtle Beach Airforce Base + Airport

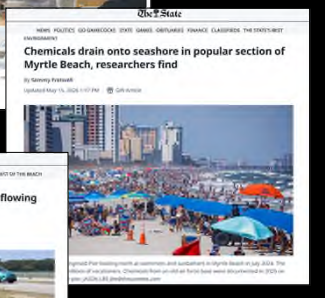




		Total	"Legacy"			"Modern"	(cautious: ballpark ##)	
Location	**Sample**	**PFAS**	**EPA-6**	**PFOS**	**PFOA**	**Mod 26**	**EPA6/TOT %**	**Mod/EPA6 %**
E' drainage of modern MB airport	water	3,674	2,720	1,808	140	892	74	33
E' drainage of modern MB airport	water	19,278	13,637	9,368	824	5,180	71	38
SE' drainage @ Hwy17	water	6,247	4,573	3,129	246	1,575	73	34
SE' drainage @ Hwy17	water	15,951	11,033	7,063	728	4,498	69	41
S' drainage @ Hwy17	water	851	604	274	40	226	71	37
S' drainage @ Hwy17	water	978	706	300	40	253	72	36
Midway Swash # Ocean Blvd	water	1,446	1,096	661	54	335	76	31
Midway Swash # Ocean Blvd	water	1,096	796	500	43	277	73	35
Midway Swash # Ocean Blvd	water	1,155	826	449	55	298	72	36
Midway Swash # Ocean Blvd	soil	10,700	10,700	10,700	0	100	100	1
Midway Swash beach pond	water	**1,171**	1,068	974	41	100	91	9
Midway Swash beach pond	foam	**903**	651	344	43	230	72	35

Myrtle Beach Airforce Base + Airport



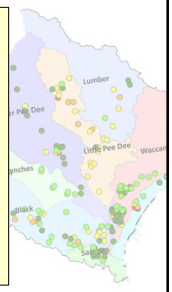


Examples…

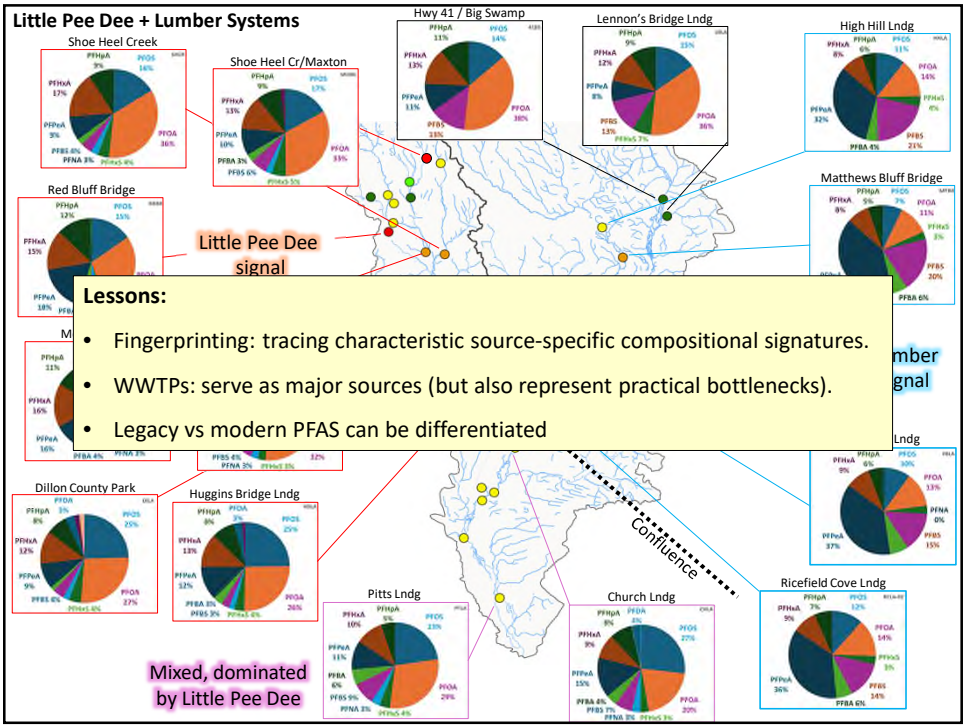
System	TOT av	TOT max	EPA6 ('legacy')	*n*
Pocotaligo R.	92	160	70	*6*
Black R.	44	128	28	*22*
Little Pee Dee R.				
Lumber R.				
Great Pee Dee R.				
Lynches R.				
Waccamaw upst				
Conway WWTP				
Wacc. downstre				
Waccamaw R. (tidal)	31	39	20	*2*
AAIW (tidal)	8	10	7	*3*
Sampit R. (tidal)	13	31	11	*10*
MB airport (swash)	4,795	19,227	3,428	*11*

Lessons (examples)**:**

- If PFAS concentration very low, then solely legacy PFAS.
- Most rivers: equal influence of modern and legacy PFAS sources.
  - Modern PFAS (industrial, residential) go through WWTPs.
- MB airport/airbase: 30% PFAS from the modern airport.



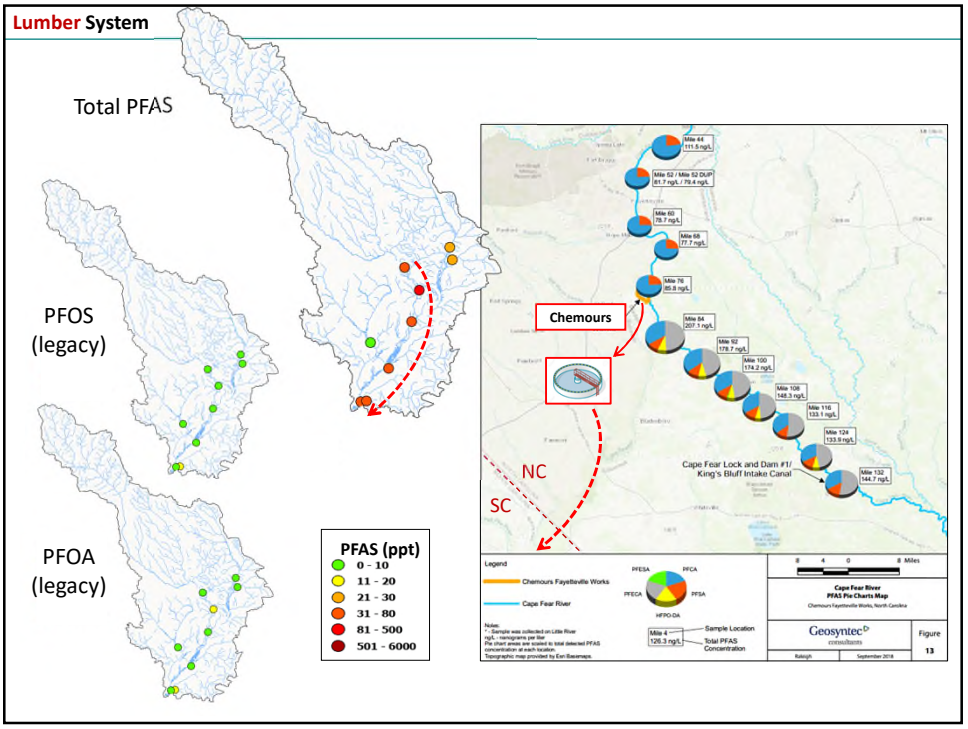
Little Pee Dee + Lumber Systems



Lessons:

- Fingerprinting: tracing characteristic source-specific compositional signatures.
- WWTPs: serve as major sources (but also represent practical bottlenecks).
- Legacy vs modern PFAS can be differentiated

Lumber System



PFAS Concentrations in Water vs Soil

System	TOT av WATER	TOT av SOIL	TOT max	EPA6 ('legacy')
Pocotaligo river	92	6,219	11,534	4,361
Spray fields, on-site ditches	84	9,507	14,063	2,574
Spray field, river creeks	56	15,721	41,760	2,651
MB airport, creeks + swash	4,795	10,700	10,700	2,109
Georgetown inner harbor	13	3,510	3,510	708
Former DuPont, drainage leaks	64	2,812	5,265	793

** All numbers: ppt PFAS*

Lessons:

- PFAS effectively accumulates in substrate.
- Substrates act as long-term sink + source.
- Though concentrations in water might not sound alarming, the overall PFAS volumes discharged seriously matters.
- "Solution is dilution" approach does not work with forever chemicals.

PFAS Concentration (ppt) vs Actual Volume Transported Per Time

Great Pee Dee

@USGS Pee Dee gauge

Dry-year conditions (!)

Av. water discharge	3,500 cfs	100 m^3/s
Av. PFAS concentration	25 ppt	0.000025 gr/m^3
Av. PFAS discharge		0.0025 gr/s
		79 kg/yr
		175 lb/yr

Big Questions:

- ***High-discharge*** vs ***low-discharge*** conditions?
  - Change in *concentrations* of PFAS discharged?
  - Change in *overall amount* of PFAS discharged?
- ***Remobilization*** vs ***dilution*** during dry – wet – flooding scenarios?

PFAS in the SC Watersheds: Outlook – Suggested Research Targets

WINYAH RIVERS ALLIANCE

a) Freshwater fish tissue across all river watersheds:

- Accumulation in this traditional food source?
- Species-dependent bioaccumulation level?

b) Flooding impacts:

- PFAS concentration vs dilution?
- Mobilization vs absorption/accumulation?
- Local rainfall vs regional storm events?

c) Monitoring major hotspots:

- Rivers: a) Pocotaligo b) Upper Little Pee Dee c) Lumber
- Coastal: Midway Swash / Beach / Market Common

d) Monitoring variability throughout the years:

- Upper Little Pee Dee, Lumber (from NC), NC tributaries
- Pocotaligo, Black River (Sumter)

e) Role of environmental controls (rain, temp, DO, Sal, discharge, tides, etc.) **in an 'outdoor lab':**

- Midway Swash and the coastal ocean
  (swash water, ocean water, fish, oysters, soil, foam, aerosols)
- Bucksport 'peninsula'
  (WWTP, spray fields, sand beds, lagoons; traditional community; new development)